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Studies in Marine Geophysics and Underwater Sound from drifting ice stations.

Contents

I. Operations at Fletcher's Ice Island (T-3) and work at Lamont

1) Navigation

During the period the island drifted north-northeast from 80-39.0N 157-49W on January 1, to 83-12.2N 153-27W on June 30. The satellite navigation set was inoperative during January and parts of February, March, and April because of problems in the receiver and data processor unit. In spite of this, over nine hundred successful satellite fixes were obtained, along with seventy celestial positions. More than one hundred of the satellite fixes were processed by the computer on the station. January and May saw the largest drifts, with movements to the north and east of 154 and 128 miles respectively. The other months showed smaller drifts of 90 miles or less, with much meandering. Several counterclockwise loops with 3-4 mile diameter were experienced between February and May while the island was moving northward in the vicinity of 157^{o}West longitude. The overall distance between fixes for the six month period was 582 miles, the net distance was 156 miles, and the meandering coefficient was 3.7. The island rotated 23.4 degrees clockwise during this time, with the island azimuth increasing relatively smoothly from N107.8^{o}E to N131.2^{o}E.

2) Bathymetry

The drift track for the period traverses the northwestern arm of the Canada Abyssal Plain, from the area west of the northern extension of the Chukchi Rise to the southern margin of the Alpha Rise. Soundings were continuous except for a few days recording lost because of electronic failures in the transmitter. North of the Chukchi Rise, the island crossed a 3620 meter deep bench and a small ridge rising to 3132 meters before drifting out onto the abyssal plain at 3800 meters. The depth remained almost constant until June, when the island repeatedly traversed an isolated topographic high shown at 83-12N, 155W on the recent Canadian Hydrographic Office chart 897. Minimum depths of approximately 2100 meters were reported.

3) Gravity

More than eleven hundred gravity readings were obtained with the Lacoste and Romberg G-27 gravity meter, and two calibration ties were made with Barrow in late February and early June. In late March, meter G-65 was brought to T-3, and 176 additional readings were made with this damped instrument. Although anomalies have yet to be computed, some small variations appear to be related to buried features on the margins of the abyssal plain.

4) Magnetics

Total intensity measurements were made throughout most of the period. Some small gaps result from noise problems in the instrument, and several days were lost when the sensing head was recovered from Colby Bay during a threatened breakup of the bay ice. Large magnetic storms were reported in June, but the details are lacking as the records have not yet returned from the station.

5) Seismic Profiler

The seismic profiler was inoperative during most of the period because of difficulties in triggering the sound source and high system noise levels. Records taken in mid-January and March show acoustically transparent sediments overlying reflecting horizons at 630 meters and 1200 meters.

6) Marine Geochemistry

A set of five samples for radiocarbon analysis was obtained during April and May 1968. These samples are from the cores of Arctic water masses and are part of a continuing analysis of radioactivity in the Arctic Ocean. The results indicate a rapid intrusion of Pacific water into the Arctic Ocean in comparison with the other water masses.

7) Ocean Currents

The current meter string installed in April 1967 now has a number of malfunctions and will be retrieved this coming summer. Nineteen vertical profiles of currents at closely-spaced intervals were taken during May. Two hydrographic stations were also taken during this period.

8) Underwater Sound

Long-Range Propagation Experimental Work.

An experiment to study the effects of range and bathy metry on signal strength and character was completed in May. Two-pound TNT charges set to explode at a depth of 800 feet were dropped into open leads from a Navy aircraft along six flight lines radiating from T-3. Listening was done aboard T-3 which was over the Canada Abyssal Plain in 3000 m of water. A total of 40 shots were recorded. Two of the profiles, which were made under very favorable weather and ice conditions, provided an extremely fine set of data. Twenty-one shots dropped at 50 to 125 km intervals were recorded on these profiles. One of the profiles was over the Canada Abyssal Plain (except for a short segment of path over the continental margin) and the second profile passed over about equal segments of the Canada Abyssal Plain and the Alpha Cordillera. Of all six profiles, transmission along the profile in the Plain was best. At the extreme range of 1100 km, peak signal intensity in the band 10 to 100 CPS detected by the hydrophone at a depth of 100 feet was + 3DB re 1 dyne/cm^2, or about + 7DB above the ambient noise in this band.

Theoretical Studies.

A useful approximate solution of the wave equation for the Arctic sound channel is obtained by the WKD approximation. This solution provides a connecting link between geometrical acoustics (ray theory) and the rigorous solution of the wave equation in terms of normal modes. A comparison is being made

between dispersion and amplitudes computed from the rigorous model solution for a stratified ice-covered Arctic Ocean and the WKB solution for the corresponding models but with the ice layer neglected. Phase- and group-velocity dispersion computed from the WKB solution is in close agreement with the rigorous model solution for waves corresponding to the second and higher modes. The WKB solution is particularly convenient where more than three modes contribute to the signal because the computations can be done extremely fast on a high-speed digital computer. The WKB solution has a further advantage in that dispersion as a function of frequency and amplitudes as a function of range, frequency and depth are obtained from parameters computed in ray tracing computations and these parameters are therefore automatically available for a standard ray interpretation of the acoustic signal.

Ambient Noise.

Ice vibrations on the pack ice surface and pressure levels at depth were measured during April and May near the edge of T-3. Three matched seismometers, one vertical and two horizontal instruments oriented at right angles, were used to detect the ice vibrations. Four hydrophones at depths of 15, 50, 100 and 200 feet below sea level beneath the three seismometers detected pressure fluctuations. Waves in the frequency range from 1 HZ to 3 KHZ were recorded. The predominant source of noise was large-scale ice motion at the boundaries of nearby floes. Flexural waves from this ice motion varied in amplitude by as much as 50 DB over an interval of one day. The deep hydrophones do not detect the flexural vibrations but pick up sound waves generated by the ice movement. Commonly, sounds can be heard corresponding to pieces of ice grinding against each other and breaking up. Other sources of noise commonly observed are:

1) Local thermal cracking
2) Local small-scale ice fracture
3) Wind driven snow over the ice surface
4) Animal sounds - apparently whales and seals

II. Data Analysis

1) Navigation

A computer program has been developed to increase the accuracy of celestial positions determined by observations of the sun and stars. Generating its own celestial coordinates and refraction corrections without reference to tables, the program appears to offer at least a five-fold increase in accuracy over previous hand computed fixes. Past fixes are now being reworked.

Another program has been written to compute the most probable movements of the ice island between fixes, relying on wind information. All the navigation from 1962 to mid-1967 has been run, and the interpolated positions are very encouraging. The program works along the guidelines of Nansen's Rule, and periods of up to 20 days between fixes have been examined.

Several plotting programs have also been written to allow the speedy plotting of large quantities of track and observational data on either a Polar Stereographic or Polar Azimuthal Equidistant projection.

2) Gravity

A program has been written for determining the base values for the gravity meter during calibration ties at Barrow, and for computing the instrumental drift corrections between ties. Earth-tide corrections are automatically computed. Results from this program are used in another program which uses navigation, depth, and original gravity data to produce a geophysical data card with time, interpolated position, corrected depth, total gravity, Bouguer and free air anomalies, and if magnetic information is provided, average magnetic field. All gravity data taken from T-3 have been put on cards, and are now awaiting the final navigation, and computation.

3) Magnetics

A computer program has been developed to accept hourly magnetic readings, and to compute hourly magnetic field strengths, each value being an average for the 24-hour period centered about that hour. In this manner it is possible to filter out most of the large diurnal variation found in the Arctic. All data from 1962 to early 1968 have now been processed in this fashion, and are available on cards.

4) Ocean Currents

Computer programs have been developed for the reduction of data recorded by the current meters. The speed calibration corrections and conversion from magnetic to true azimuth are accomplished with the program. The components of ice velocity, found from the SAIL program, are then subtracted from the current components to give true current speeds at the various depths.

III. Meetings Attended and Papers Published

K. Hunkins attended a meeting on "Remote Sensing in the Polar Regions" held in Easton, Md. on Mar. 6-8, 1968 as a panel member on remote sensing in polar oceans.

He also attended a meeting on "Long-Range Polar Objectives" sponsored by the Dept. of Transportation in Easton, Md. on Mar. 4-6, 1968.

As Chairman of the Panel on Oceanography (Committee on Polar Research), he attended a meeting in Denver on 27 Apr. 1968.

Publications:

Hunkins, K., "Seismic experiments on Sea Ice" in Int'l. Dictionary of Geophysics, Pergamon Press.